

DEVELOPMENT OF SOURCE-DETECTOR ASSEMBLY AND MOVEMENT CONTROL OF EXPERIMENTAL COMPUTED TOMOGRAPHY

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ABSTRACT

This paper is on development of Source-detector assembly & movement control of Experimental Computed Tomography scanner which can be used in institute laboratory, colleges for learning which is efficient to understand the actual Computed Tomography working. This paper covers source-detector assembly, movement control of Experimental computed tomography.

KEYWORDS: ECT, Source and Detector Array, Movement Control of Gantry Assembly

Abbreviations: CT-Computed Tomography, Experimental Computed Tomography-ECT

INTRODUCTION

Computed Tomography (CT) is a powerful technique for producing cross sectional images of an object. CT consists of important parts which are source, patient, detector, data acquisition system & image reconstruction. Experimental Computed Tomography is model similar to CT. It also generates cross-sectional, two-dimensional images of the object. In ECT the attenuation at different points in an object is measured to obtain the information which is used to get desired image as an output. Hence for attenuation, light is selected as source instead of x-ray and photo transistor is used as detector to sense the incident light into electric response. Thus source and detector have greatest impact on image generation. In ECT source and detection technologies evolved to support major CT imaging trends such as increasing number of slices, increased speed of acquisition. CT sources evolved to support larger coverage per rotation and detector elements arrays are the main enabler for the emergence of multi-slice ECT scanners.

Figure 1 shows that block diagram of ECT which consist of source & detector array, gantry assembly, D.C motor, encoder, microcontroller, data acquisition and computer. The block diagram of ECT is a four-step process: The transmission of light beam is measured through all possible straight-line paths as in a plane of object and attenuation of light beam is estimated at points in the object & transmitted light is then measured by a ring of sensitive detectors around that object. The source & detector are fixed on mechanical assembly of gantry in opposite direction which rotates from 0 to 360° by using D.C motor with position encoder output & controlled it by PIC microcontroller. Then projections are taken at every 10 degree in translation manner. Signals obtained from the array of detectors are filtered, modulated and passed through DAQ card to computer. Data acquired from many different angles is used for image reconstruction to get tomographic image using different reconstruction techniques. Hence it is important to realize that collecting many projections of object and light beam play important role in ECT image formation. Each component of an ECT system plays a major role in the accurate formation of image.

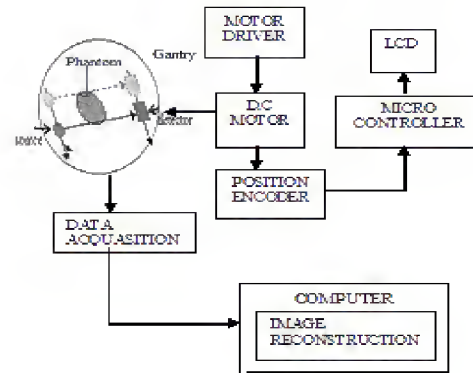


Figure 1: Experimental Computed Tomography

SOURCE AND DETECTOR

The attenuation coefficient is a quantity that characterizes object is penetrated by a beam of light. The attenuation coefficient is also called linear attenuation coefficient or absorption coefficient. The measured intensity I of transmitted through a layer of material with thickness is related to the incident intensity I_0 according to the inverse exponential power law that is usually referred to as Beer–Lambert law:

$$I = I_0 e^{-\alpha x}$$

Where x denotes the path length. The attenuation coefficient is α . Beer-Lambert law states that there is a logarithmic dependence between the transmission (T), of light through a substance and the product of the absorption coefficient of the substance (α), and the distance the light travels through the object (x). Thus according to this law the components are chosen accordingly. Source selected is light and detector as is phototransistor. In this assembly laser diode is used as light source because it is monochromatic & coherent. It is red light laser diode with output wavelength 650nm and operating voltage range between 2.3V to 3.5V. It has diameter of 6mm. output power 5mV. It has low threshold current, high output power. Source is selected as laser diode, laser light will pass through the phantom and the attenuated light containing information will be detected by phototransistor which acts as detector.

The detector used in this assembly is L14G2 photo transistor which is very sensitive for light detection. It is an NPN transistor with peak wavelength of 940 nm, maximum dark current of 100nm while in light its current is 500 μ A. When light incidents on this junction, electrons are generated by the photons. These electrons are injected in the base of phototransistor. The current gain of the transistor amplifies the resulting photocurrent at the base collector junction. Thus a phototransistor conducts in the presence of light and remains in off mode in absence of light.



Figure 2: Laser Diode & Phototransistor

PHANTOM

Object through which light is emitted is phantom. Phantom is made up of transparent glass which consisting impregnated image in it. It is used because laser light passes through it easily such that we get output at the detector in the form of voltage variations.



Figure 3: Phantom

MECHANICAL ASSEMBLY OF GANTRY

Mechanical arrangement in ECT play vital role to get slice image. The structure frame & gantry assembly of ECT both are important aspect in movement control of source & detector on phantom table. ECT gantry can be angled from 0 to 360 degree toward a forward or backward position by using movement control unit. The mechanical assembly for this single beam source & detector ECT is comprised by strength and rigidity structural frame in stainless and carbon steels, rotating table, source shield and collimator with pneumatic exposure system, translator, rotary stage, drivers and motors. The use of suitable gears has given a good repeatability and high accuracy in the degree of veracity. Source & detector array placed are positioned opposite each other due to this arrangement laser light will get passed through phantom & detect the signal. The scanner was setting for 10 degree per rotation and 1 projection for each detector totalizing 360 projections. Rotate motion will be done by motor & translate motion will be done by logical programming. It is established that translate-rotate arrangement scanner unit has a good spatial resolution acceptable given the size of the used phantom in this study. For achieving slice image it required projection from gantry rotation by using motor with position encoder which is controlled by Microcontroller.

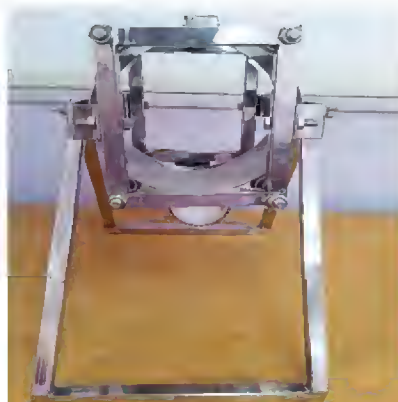


Figure 4: Mechanical Assembly of Gantry

Position Encoder

Position encoder is an electromechanical device used to convert mechanical position of shaft to digital electrical signal. The actual speed of DC motor will be measured by encoder and feedback to microcontroller. It provides a position value as the shaft of that motor which is rotated & also used to control the motor in desired angulation. The encoder value is transmitted to a controller in a form of square pulse which is done by binary coding. It provides a specific number of equally spaced pulses per revolution.

Position encoders will be constructing by using a rotating glass or plastic disc containing concentric rings which have patterns etched onto them which is shown in Figure 4. IR transmitter will be used to shoot light through a grid; the grid projects a pattern onto the rotating disc. IR receiver will be used on the other side of the rotating disc to read the pattern of light being passed through. The pattern on the grid, combined with the pattern on the rotating disc gives a code of 1's (ON) and 0's (OFF) in a binary format. The signals can be connected directly to an input port and all decoding and counting performed in microcontroller. These interfaces will give the position value to the controller using codes to represent actual position or each degree of gantry rotation.

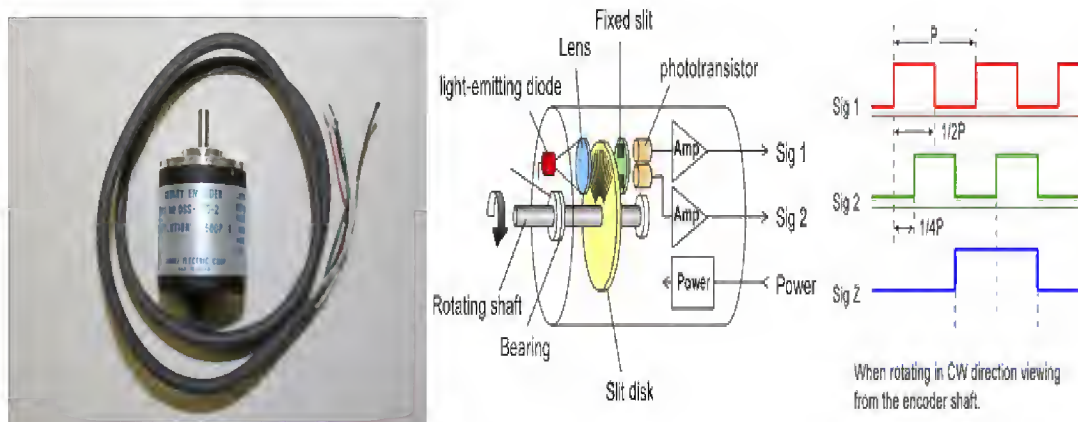


Figure 5: Position Encoder

- **Microcontroller**

PIC16F877A Microcontroller is used as the controller to control DC motor speed at desired speed. Microcontroller takes input from position encoder & control the motor. In microcontroller, it will calculate the error between the desired speeds with the actual speed. The error will determine duty cycle of pulse-width- modulation (PWM) in microcontroller. Then, the duty cycle will send to DC motor driver either accelerate or decelerate DC motor to maintain it at desired speed. Also synchronization of motor & source can be controlled using microcontroller.

- **Phantom Table**

Rack and pinion can be used for translation motion of phantom table. It is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion of the rack. 2 Limit switches fixed at the end of table plate to control the forward & reverse motion of phantom table.



Figure 6: Phantom Table

ELECTRONIC ASSEMBLY

The source and detector assembly is controlled by using Microcontroller 8051. This assembly is mounted inside the gantry and gantry is rotated stepwise so there is need of wireless transmission for collecting the data. RF module is used for this transmission in the range of 85 to 108 MHz.

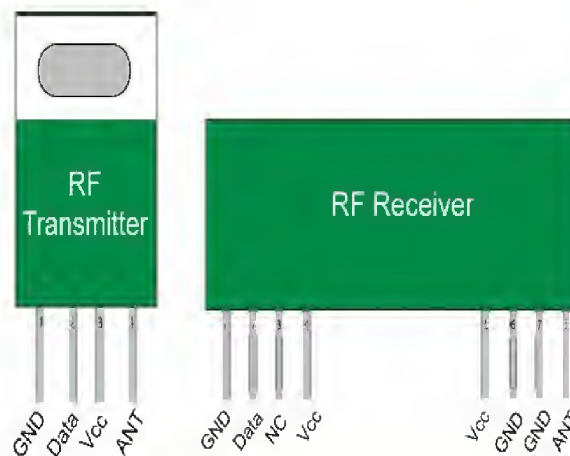


Figure 7: RF Module



Figure 8: Source-Detector Array

DATA ACQUISITION

Data Acquisition (DAQ) is defined as the process of taking a real-world signal as input, such as a voltage or current or any electrical input, into the computer, for processing, analysis, storage or other data manipulation or

conditioning. A DAQ system consists of sensors, DAQ measurement hardware, and a computer with programmable software. Compared to traditional measurement systems, PC-based DAQ systems exploit the processing power, productivity, display, and connectivity capabilities of industry-standard computers providing a more powerful, flexible, and cost-effective measurement solution.

IMAGE RECONSTRUCTION

This data is collected at various angles from 0 to 360 degrees. Any of several algorithms available can then be used to reconstruct its 2D cross-sectional image from its projections. Fundamentally, tomography deals with reconstruction of an object from its projections. The technique of tomography consists of passing a series of rays (in parallel, fan beam) through an object, and measuring the attenuation in these rays by placing a series of detectors on the receiving side of the object. These measurements are called projections. There are many methods of collecting the projection data. The projections with data which will be acquired will then be used for image reconstruction using various image reconstruction techniques to form reconstructed image.

CONCLUSIONS

It is concluded that design an experiment that served as an introduction to computed tomography. It required less time for preparation and data collection and analysis. With the reduction in scan time, students are now able to perform multiple scans of objects of differing sizes, locations & clear their Concept regarding CT images. [5] A. C. Kak and M. Slaney, Principles of Computerized Tomographic Imaging: IEEE Press, 1988. [6] G.N. Ramachandran and A.V. Lakshminarayanan, "Three dimensional reconstruction from radiographs and electron micrographs: Application of convolution instead of fourier transforms," Proceedings of the National Academy of Sciences, vol. 68, pp.

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